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# **The Endogenous Evolution of Market Institutions**

## **An Experimental Investigation**

by

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### *Abstract*

We study an experimental market in which the structure of the information flows is endogenized. When making an offer, traders choose not only the price at which they are prepared to trade, but also the subset of traders they want to inform about the offer. This design allows for two extreme institutions as special cases. If traders always inform *every* other trader about each offer, the resulting institution is equivalent to a double auction. If, on the other hand, traders always inform *only one* other trader about each offer, the resulting institution is equivalent to a decentralized bargaining market. The institution that actually evolved in the experiments, however, was in between the two extreme cases. Subjects typically informed all traders of the *other* market side, but none of their *own* side. This endogenously evolving institution, however, turned out to have the same properties as the double auction.

*Keywords:* market institution, information structure, efficiency;

*JEL-classification:* C9, D4, L1;

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## 1. Introduction

The formation of a market requires a group of people some of which want to buy and some of which want to sell. For the (Walrasian) theory of market clearing this is all that is needed. As soon as preferences and cost functions are specified, equilibrium analysis can be applied. However, actual markets are not merely characterized by demand and supply. Market exchange does not take place in an institutional void. It requires a framework in which action and message sets are specified, and in which a process of matching and price formation can take place.

Interestingly, an enormous variety of market institutions can be observed in the field. For example, the process of matching and bargaining at the bazaar is completely different from the rules that govern financial markets; the typical (Dutch) rules at flower auctions are different from the (English) rules at art auctions; real estate is sold both at auctions and by means of direct negotiations; both call markets and continuous double auction markets are used to exchange financial assets. Hence, trading institutions do not only vary across different goods - different market institutions exist even for the same good.

There is some empirical evidence (e.g., Lusht, 1992, Stoll and Whaley, 1990) and a lot of experimental evidence that the details of the market institution are not inconsequential. Properties that are affected by the trading rules include the efficiency of the market outcome, the speed of convergence towards equilibrium, and the distribution of surplus over the market participants (Holt, 1995, Plott, 1982; see also Smith, 1982, for a description of the concept of institutions in the context of experiments). Given this finding that "institutions matter", one wonders which market institutions are likely to arise and evolve endogenously. Furthermore, can we be confident that actual markets will be characterized by efficient institutions? Are there circumstances under which inefficient trading rules arise and persist, or are usually certain forces and mechanisms present that drive a market towards efficient organization?

How trading institutions emerge and develop is not a well-understood or documented process (Friedman and Rust, 1993). Basically, there are two types of explanation for the formation of institutions (Rutherford, 1994). One approach concentrates on the design and introduction of institutions as the intended outcomes of rational self-interested actions. The other approach focuses more on invisible hand and evolutionary processes, in which institutions emerge as the unplanned and aggregate result of individual acts. This approach is very explicit in the Austrian tradition which sees institutions as the "results of human action but not of human design" (Hayek, 1967; see also Schotter, 1981)<sup>1</sup>.

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<sup>1</sup>A theoretical model that combines elements of both approaches (intended design and aggregate

In our study we follow the latter approach. We examine how the interaction between traders shapes the properties of the trading mechanism. This corresponds with Friedman and Rust (1993, p. xvi) who hypothesize that "many of the trading rules might be better regarded as commonly understood 'customs' rather than precisely codified regulations".<sup>2</sup>

To study the process of institution formation one possibility would be to look at historical evidence. However, origin and development of trading institutions are often not well-documented. The same is true for the environmental factors (e.g., demand and supply structure, product characteristics, transactions costs) that may shape the institutional evolution. Furthermore, it is very difficult to assess the efficiency properties of institutions on the basis of historical records. These problems arising from the lack of control and observability can be overcome by an experimental investigation where one can fix the environment and observe the properties of the trading institution.

It should perhaps be noticed that a reference to the efficiency properties of a market institution by itself cannot serve as a sufficient explanation for its origin or persistence. There is no guarantee that evolutionary or competitive forces lead to efficient outcomes. There may be self-reinforcing mechanisms at work that hinder a development towards efficiency and that make it hard to change an institution once it has come into place. Once a market gets momentum, its institutional rules are likely to become entrenched, or, at least, to be path-dependent (Friedman, 1993). Also there may be issues of free-riding or (market) power that prevent an efficient institution from forming (North, 1993). Hence, there is no a-priori reason to expect an efficient institution to evolve.

What is it that makes market institutions matter? The starting point of our analysis is the well-known experimental result that the continuous double auction (DA) is a type of trading institution that seems to invariably generate outcomes consistent with the predictions of the competitive model. This institution allows traders to make bids (offers to buy) and asks (offers to sell) and to accept other traders' offers at any moment. An important property of the DA is that all traders are informed about the outstanding bids and asks. As a consequence, the process of price formation and matching is a public and multilateral process. At the opposite extreme is a market institution with decentralized

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result) is advanced by McAfee (1995); see also Peters (1996). Rational 'designers' choose the reservation price of an auction, but they compete for clients (potential buyers) with other designers. Hence, for the success of a design also the aggregate of the individual decisions of the buyers is decisive.

<sup>2</sup>This approach does not mean to imply that trading institutions should be fully understood as the unintended and unplanned outcome of disconcerted actions. The origin of most institutions clearly involves elements of plan and purpose. The premise, however, is that many institutions have started as informal rules of conduct and spontaneous mechanisms, perhaps to become later formalized and enforced by some external authority.

matching and private bilateral bargaining. This is the institution originally employed by Chamberlin (1948) in the very first experimental market study (see also the so-called "telephone markets" in Grether and Plott, 1984, and Hong and Plott, 1982). Under this institution traders are restricted to contact other traders only one by one, and the offers and counteroffers made in these bilateral encounters are not revealed to other traders. This decentralized bargaining market (DBM) was found to generate inefficient outcomes, incongruent with the competitive model.

These results indicate that the differences in the information structure as well as in the matching procedure have a substantial impact on market performance. This was also suggested in the literature. When Vernon Smith designed the first experimental DA market, he referred to the important fact that in Chamberlin's market "each trader's attention is directed to the one person with whom he is bargaining, whereas in my experiments each trader's quotation is addressed to the entire trading group" (1962, p.114). Similarly, Holt (1995, p. 373) argues that the "price variability, which goes with decentralized trade, can generate the inefficient trade of extra-marginal units". Hence it seems that the structure of the information flows and the matching procedure are crucial features of a market institution (see also Joyce, 1983, and Gode and Sunder, 1997).

In the present study, we endogenize both decisive structures of the market, information flow as well as matching procedure. When a trader submits an offer, she<sup>3</sup> decides who will be informed about this offer and to whom it applies. She can choose to inform any number of traders from both the own and the other market side about her offer. If a potential trading partner is informed about an offer, it also applies to her. Hence, if each trader always chooses to inform every other trader about her offer, the information structure of the market is identical to that of a double auction - every trader is always informed about all outstanding offers and every offer applies to every potential trading partner. In that case the market mechanism is in effect a multilateral process with a centralized information and matching structure. If, on the other hand, each trader always chooses to inform only one other trader about her offer, price formation and matching are a completely decentralized process as in Chamberlin's experiment.

In our study we implement a 'pure' market environment with a homogeneous good, several buyers and sellers, and no exogenous transaction costs. From previous experimental studies it is known that the double auction trading institution typically generates competitive outcomes in such an environment. Our endogenous market institution allows us to examine whether the double auction institution will tend to emerge as the aggregate result of individual traders' decisions, or whether the

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<sup>3</sup>The sex of the generic experimental subject referred to in this paper has been determined by chance (tossing a fair coin). It turned out to be female.

market institution that emerges is more alike to the decentralized bargaining market. Furthermore, whichever institution evolves endogenously, we can analyze its properties and compare these to those of the two benchmark institutions.

Our paper is organized as follows. In the next section we describe the experimental design. In Section 3 we present the results, and Section 4 contains a concluding discussion.

## **2. Experimental Design**

Our experimental design consisted of three treatment conditions. In the first treatment, we endogenized the information structure of the market. When making an offer, a trader not only specified the price at which she was prepared to trade, but she also indicated which subset of the other traders she wished to inform about the offer. We called this the endogenous market (EM) treatment. The EM treatment incorporated both the double auction trading institution and the decentralized bargaining institution as special cases. However, there was of course no guarantee that any of these two special cases would actually ensue in the experimental sessions. To allow for a square comparison of the outcomes in our EM market with the outcomes of these two extreme institutions, we also employed two controls treatments in which we enforced the rules of the double auction (DA treatment) and the decentralized bargaining market (treatment DBM), respectively. Apart from these institutional manipulations, our design followed the conventions that have been developed regarding experimental markets (see the Appendix for a set of instructions).

### *Market structure*

Each experimental market session consisted of a sequence of one practice round and 18 trading rounds. Each trading round lasted a maximum of three minutes. Markets were inhabited by 12 traders, 6 buyers and 6 sellers. Traders retained their roles throughout the session. In a trading round, each individual trader could trade at most one unit. The private value of a trader (cost value or redemption value) changed from round to round. The set of values, however, remained the same, and this was common knowledge. Hence, the market environment (i.e., the induced aggregate demand and supply functions) were constant across the practice round and the 18 rounds of the experiment.

The demand and supply functions induced by these values are illustrated in Figure 1. As can be seen, the competitive equilibrium was at a quantity of 4 units and a price in the interval  $[30, 35]$ . Hence, for both buyers and sellers there were four infra- and two extra-marginal traders. The induced demand and supply schedule were, of course, to a large extent arbitrary. Our main consideration was

to strike a balance between the probability of an extra-marginal trade occurring (a high probability requiring elastic schedules), and the efficiency loss associated with an extra-marginal trade (a large efficiency losses requiring inelastic schedules).

Insert Figure 1 about here

Besides values, traders were also assigned ID-letters: A, B, C, D, E, and F for buyers, and U, V, W, X, Y, and Z for sellers. These ID-letters were randomly (re)assigned to the traders at the beginning of each round. The assignment of ID-letters was neither related to the assignment of values nor to the "real" identity of the subjects. The subjects were informed about this.

### *Trading institutions*

#### (a) Endogenous Market (EM) treatment

Buyers could try to buy by making bids, and sellers could try to sell by making asks. When making an offer (an ask or a bid), a trader had to enter a price at which she was prepared to trade. She also had to enter the IDs of those traders she wanted to inform about the offer. A trader was forced to enter the ID of at least one trader from the other market side, i.e. the ID of at least one potential trading partner. This constraint was imposed to prevent traders from sending 'fake' offers to only their own market side, i.e. to only their competitors. Furthermore, offers that could lead to negative profits were not permitted. Offers could be adjusted at any moment by simply submitting a new offer. Then the old offer became invalid. Hence, each trader had at most one outstanding offer. Since everyone could trade at most one unit, a trader who had already made a transaction could no longer make offers.

As long as a trader had not traded in that round, she was allowed to accept any offer of a potential trading partner that she was informed about. Again we enforced the restriction that an offer could only be accepted if it led to a non-negative profit. We did, however, not enforce the rule that a trader always had to accept the best price-offer available. When an offer was accepted, it was withdrawn from the market, and those traders that had been informed about the offer were also informed that a transaction had occurred at that price.

#### (b) Double Auction (DA) treatment

In the DA treatment, traders did not have to enter any trader ID-letters when submitting an offer. All offers were automatically sent to all other traders, i.e. to all potential trading partners as well as to all competitors. All traders were also informed when and at what price a trade occurred. This treatment boiled down to the standard continuous double-auction market, with the exception that trader IDs were

added and that traders were not restricted to accept the best offer available.

#### (c) Decentralized Bargaining Market (DBM) treatment

In the DBM treatment, traders were requested to enter one and only one ID-letter of a potential trading partner when they entered an offer. Furthermore, when a transaction occurred, nobody but the two parties involved was informed about this.

It is now easy to see that the two control treatments were special cases of the EM treatment. If in EM all traders always informed all other traders about their offers, the information structure of the market was identical to that in the DA treatment. If, on the other hand, all traders always informed exactly one potential trading partner about their offers, the information structure would be identical to that of the DBM treatment.

#### *Information display*

The trading process was handled by means of networked computers. At any point in time a trader's computer screen displayed the following information: the round number, the time left for trading, a trader's role (buyer or seller) and ID-letter, the cost or resale value, and a trader's total profits up to that round (the Appendix gives a sample screen).

In the middle of the display were the lists of ask- and bidprices, one above the other. For treatments EM and DBM these lists only contained those offers that the trader was selected to be informed about by the sending party. Both ask- and bid prices were ordered from high to low, and for each offer also the ID-letter of the sender was indicated.

Finally, at the bottom of the screen, there was a row with the prices of those accepted offers that the trader had been informed about. Only prices were revealed and not the IDs of the transacting parties.

#### *Procedure*

For each of the three treatments, four independent experimental sessions were run. Students at Tilburg University were recruited as subjects through announcement in the university bulletin and in classes. Participants were solicited for a two hour decisionmaking experiment which would earn them money. Fifteen subjects were registered for each experimental session to allow for no-shows. In session DA1, however, only 10 subjects showed up. This sessions was run with 10 traders, using the design of Figure 1 with one buyer (redemption value 50) and one seller (cost value 15) excluded, leaving the range of equilibrium prices unchanged.



Upon arrival in the lab, subjects drew an envelop with a seat number. If more than 12 subjects showed up, one to three empty envelopes were added to the stack of seat numbers. The subjects drawing an empty envelop received 10 Dutch guilders (Hfl) for showing up and left the room. Once the remaining subjects were seated, the instructions for the experiment were distributed and read aloud by the experimenter. Then the subjects were given some minutes to study the instructions on their own pace, and to privately ask questions. After the practice round, the 18 rounds which determined subjects earnings were run. After round 18 the subjects privately received their total earnings and left the room.

Sessions lasted about one and a half hour. Earnings were about Hfl 52 on average, and ranged between Hfl 32 and Hfl 65. At the time of the experiment 1 Hfl exchanged for about \$ 0.50.

### 3. Results

First we examine which market institution actually evolved endogenously in the EM treatment (Result 1) and then we compare prices (Result 2) and efficiency levels (Result 3) across the three different treatments (EM, DA and DBM).

#### *Result 1:*

- a) In the EM treatment offers were typically sent to every potential trading partner (i.e., to every trader of the other market side).*
- b) In the EM treatment offers were typically not sent to any competitor (i.e., to no trader of the own market side).*

In order to present the evidence for Result 1 we calculated for each offer the number of potential trading partners to whom the offer was actually sent, divided by maximum number to whom it could have been sent (i.e. divided by 6). We called this variable the "dissemination of an offer among potential clients",  $D_{client}$ . Notice that  $D_{client}$  ranged between 1/6 and 1 since each offer had to be sent to at least one potential trading partner. Similarly, we defined the "dissemination of an offer among competitors",  $D_{comp}$ , as the number of competitors who were informed about an offer divided by the maximum number who could have been informed (i.e. divided by 5). Of course,  $D_{comp}$  ranged between 0 and 1.

Insert Table 1 about here

Table 1 presents mean and median values for both  $D_{\text{client}}$  and  $D_{\text{comp}}$  for each of the four EM sessions separately and averaged over all rounds. Also the percentage of offers with  $D_{\text{client}} = 1$  and  $D_{\text{comp}} = 0$  is indicated. The table shows that an offer was sent to 85% of the potential trading partners on average, with 100% being the median value. Furthermore, 77% of all offers were sent to every potential trading partner ( $D_{\text{client}} = 1$ ). A look at the session data indicates that this pattern was representative also for the individual sessions. Even in EM1, where  $D_{\text{client}}$  was lowest, an offer applied to all potential trading partners in more than half of the cases.

The dissemination of offers among competitors provided a completely different pattern. On average, only 12% of the competitors were informed about an offer, and the median value is zero. In 85% of all cases not one competitor was informed. It is evident that subjects were very reluctant to share information about their offers with their competitors.

Insert Figure 2 about here

A similar picture arises if one looks at the dissemination of asks and bids separately. Figure 2 shows the relative frequencies of the different levels of  $D_{\text{client}}$  and  $D_{\text{comp}}$ . In most cases an ask applied to all buyers and no other seller was informed about the ask, whereas a bid typically applied to all sellers while no other buyer was informed about it.

Insert Figure 3 about here

This pattern of information dissemination was stable over the time, as can be seen in Figure 3 which displays the development of average  $D_{\text{client}}$  and  $D_{\text{comp}}$  over the 18 rounds. From the very beginning of a session, subjects typically made offers to all potential trading partners and did not inform competitors, and this behavior did not change much over time. We also checked for the development of  $D_{\text{client}}$  and  $D_{\text{comp}}$  within the rounds. We found no distinctive differences between the beginning and the end of a round.

Since there does not exist a full fledged theory for the evolution of institutions we can only speculate about the reasons why this institution evolved. It seems quite plausible, however, that subjects transmitted their offers to all potential trading partners in order to maximize the probability of acceptance. Evidence in favor of this conjecture is the fact that when we control for the price the average values of  $D_{\text{client}}$  were larger for accepted offers than for nonaccepted offers. The differences were small but systematic. Another reasonable conjecture is that subjects hesitated to inform their competitors in order to avoid being outbid by their competitors. And indeed there is some evidence

that it took less long until a lower ask (higher bid) appeared on the market when competitors were informed about the previous ask (bid) than when they were not. Hence, we have at least weak evidence that the driving forces behind the evolution of the observed institution were subjects' intention to increase the probability of acceptance of offers and to decrease competition.<sup>4</sup>

Since a central information conveying institution developed only partially, it is particularly interesting to see whether the properties of this endogenously evolving institution were more in line with those of the double auction or with those of the decentralized bargaining market.<sup>5</sup>

*Result 2:*

- a) Prices in the EM-treatment were as close to the equilibrium price as those in the DA-treatment.*
- b) Prices in the EM-treatment were closer to the equilibrium price than those in the DBM-treatment.*

Insert Table 2 about here

Remember that in our design the equilibrium price was set-valued (see Figure 1). Therefore, we looked at the average absolute difference between actual prices and the equilibrium price range [30,35]. As one can see from Table 2, the average distance to the equilibrium price was even smaller in the EM treatment (0.79) than in the DA treatment (1.1). This difference between the two treatments was, however, insignificant ( $p=68\%$ )<sup>6</sup>. On the other hand, the distance to the equilibrium price was larger in the DBM-treatment (1.59) than in the EM-treatment. Furthermore, as can be seen from Table 2, even prices in session EM4 (the EM-session with the largest distance between actual and equilibrium prices) were closer to equilibrium than prices in DBM2 (the DBM-session with the lowest distance to equilibrium). Hence, the difference between EM and DBM was highly significant ( $p = 2.8\%$ ).

Insert Figure 4 about here

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<sup>4</sup>A detailed description of these data analyses is available from the authors upon request.

<sup>5</sup>Result 1 implies that also information about acceptance behavior disseminated only partly - acceptance of an offer made by a potential trading partner was observed, but not acceptance of an offer made a competitor. Therefore, subjects observed half of the transaction prices on average.

<sup>6</sup>Throughout we employed two-tailed Mann-Whitney tests with session averages as observations.

Support for Result 2 can also be found in Figure 4. This figure presents for each treatment the development of the average absolute difference between actual and equilibrium prices. In all treatments this difference showed a tendency to decrease over the rounds. But, as can be seen in the upper panel of the figure, in all but two rounds the difference was larger in the DBM- than in the EM-treatment. This was true even for the final rounds. On the other hand, as can be seen in the lower panel, the comparison between the EM- and the DA treatment did not reveal a systematic difference.

Next we look at the efficiency properties of the different treatments. As it is common in experimental market studies, we call an outcome of a certain round efficient if the participants together earned as much as possible, that is, if the sum of consumer and producer surplus was maximal.<sup>7</sup> If the sum of the earnings of all participants fell short of the maximum, trading in that period led to an inefficient result. A natural measure of this inefficiency is the percentage of the maximum earnings that was not realized in the market. Another measure is the number of inefficient rounds. Using either of these two measures we find:

*Result 3:*

- a) Efficiency in the EM-treatment was significantly higher than in the DBM-treatment.*
- b) Efficiency in the EM-treatment was as high as in the DA-treatment.*

Insert Table 3 about here

For each of the three treatments, Table 3 presents the average levels of inefficiency and the number of inefficient rounds. It turns out that in the DBM sessions the average inefficiency level was about 7%, whereas in the EM sessions it was less than 1%.<sup>8</sup> Even the most efficient DBM session (DBM4) was more than 3 times as inefficient as the most inefficient EM session (EM1). Hence, the difference between the two treatments was highly significant ( $p = 2.8\%$ ). In contrast the DA sessions were about as efficient as the EM sessions. Here the efficiency levels of the individual sessions overlap and the difference between the EM- and DA-treatment is not significant ( $p = 68\%$ ). Qualitatively the same

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<sup>7</sup>A sufficient but not necessary condition for efficiency is that the market operates at the market clearing equilibrium.

<sup>8</sup>The impact of a trade of an extramarginal trader as well as that of a non-trade of an intramarginal trader on efficiency depends of course on the supply and demand conditions. Hence, not the absolute values of the inefficiency levels but the differences in efficiency between the treatments are important.

results appear if we look at the number of inefficient rounds. In the DBM treatment 41 of 72 periods were inefficient, whereas in the EM (DA) treatment only 9 (11) of 72 periods were inefficient. Again the difference between DBM and EM was significant ( $p = 2.8\%$ ), whereas the difference between DA and EM was not significant ( $p > 50\%$ ).

Insert Figure 5 about here

In Figure 5 we depict the evolution of inefficiency over the rounds. In all treatments inefficiency was higher in earlier rounds than in later rounds. But even in the later rounds of the experiment inefficiency was much higher in the DBM- than in the EM-treatment, whereas no systematic difference between the DA- and the EM treatment was observed.

For a further examination of the efficiency properties one can distinguish between two different types of inefficiencies. A round is inefficient whenever an extramarginal buyer or seller trades. Such inefficient trades can only occur at out-of-equilibrium prices. But even in absence of inefficient trades a round may be inefficient if not all intramarginal traders strike a deal. Such an inefficient non-trade can occur if potential trading partners do not find each other or if they cannot agree on the price. It turned out that the inefficiencies that occurred during the early rounds of a session were due to inefficient trades as well as due to inefficient non-trades. If a later round was inefficient, however, this was almost always due to inefficient non-trades. This pattern emerged in all three treatments. Both types of inefficiencies, however, were much more frequent in the DBM- than in the EM treatment, whereas again no difference between the EM- and the DA treatment was discernable. We can conclude that the endogenously evolving institution prevented mismatch (i.e. inefficient trades) as well as non-match (i.e. inefficient non-trades) as effectively as the double auction, whereas the decentralized bargaining market performed worse in both respects.

#### **4. Concluding discussion**

We have seen that in a "pure" market environment a central information conveying institution evolved only partly - traders tended to inform all potential trading partners, but not their competitors. Under the resulting institution traders were on average informed about half of the offers and half of the realized prices. Nevertheless, the properties of the endogenously evolving institution turned out to be similar to those of a double auction institution. Convergence of prices to the market clearing level as well as efficiency levels were comparable under both institutions, whereas in a decentralized bargaining

market prices converged more slowly and efficiency was lower.

In order to explain convergence of prices and quantities in double auctions some authors developed models of boundedly rational traders, whose behavior depend adaptively on past observations (see e.g. Easley and Ledyard 1993, Friedman 1991, and Gjerstad and Dickhaut 1995). Our results cast doubts on the validity of these models. In our endogenous market traders observed much less offers and realized prices than in our double auction treatment. Hence, models based on adaption would predict slower convergence in the EM- than in the DA treatment, a prediction not confirmed by the data. At this stage we do not know why the double auction and our endogenous market have similar properties, but it seems clear that something more elaborate than simple adaptive behavior is needed for an explanation.

Like in our experiment also in "real world" markets we often observe that traders try to make offers to as many potential trading partners as possible. An example of that is the mail order business which sends leaflets containing offers to every household of a town or a region. But this tendency to disseminate offers among potential trading partners also interacts with how difficult and how important it is to exclude information from competitors. The more important and the easier information non-disclosure is, the less widespread offers tend to be. In some markets (e.g. the market for telecommunication equipment) potential trading partners usually sign a "non-disclosure agreement" even before an offer is made, stating that no partner is allowed to disclose any information about the offer to third parties.

The problem of information sharing among competitors is also a hotly debated issue in competition policy. The EU-commission seems to take the position that information exchange among competitors is a sign of collusion. This point of view, however, is not uncontested (see Philips 1995).

The double auction and the decentralized bargaining market are not the only special cases of our Endogenous Market design. Suppose, for example, that in our EM treatment only sellers make offers. This would be equivalent to an one-sided market institution (see Smith 1964) as it is typical for many retail markets. Suppose, furthermore, that sellers only submit 'ultimatum offers', then in effect a posted price trading institution would originate. Of course, given the 'pure' market structure that we have employed in the present paper these are unlikely suppositions, and, as our results indicate, such intricate institutions are not engendered by a pure market structure. This simple structure, however, is only taken as a natural starting point. In future research we intend to examine the effects of other environments on the evolution of market institutions. By studying the effects of, for example, product differentiation, market power, asymmetric information, and (asymmetric) transaction costs we will be able to systematically examine the impacts of the environmental characteristics of a market on the institution that develops.

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## Appendix. Instructions and computer screen

The instructions were in English but the computerscreens were in Dutch. We leave it like that below. The instructions for buyers and sellers were mirror images of each other. Below we only give the instructions and computer screen for a buyer. Below we give the instruction for the endogenous market between brackets [treatment EM], for the double auction between parentheses (treatment DA) and for the decentralized bargaining market between accolades {treatment DBM}.

### Instructions

Today we are going to set up a market in which some of you will be buyers and others will be sellers. Those of you who have drawn a "B" are buyers, those of you with a "S" are sellers. During the experiment you will have to make trading decisions and these decisions will determine your earnings. During the experiment your earnings will be denoted in points. For each point you earn you will get 30 cents for your participation. Your earnings will be paid to you privately and in cash after the experiment.

First, we will go through the instructions together. After that you will get the opportunity to study the instructions in your own pace and to ask questions. Also we will have a practice round before we start the experiment. If you want to make notes you can use the empty sheet that is on your table. Please, do not write on the instructions, and do not touch the keyboard until we are done with the instructions.

The experiment will consist of 18 trading rounds. In each trading round each buyer may buy at most one unit. Each seller may sell at most one unit. Trades are made in accordance with certain rules that will be explained below. If a buyer buys a unit in a round, her earnings are equal to the *resale-value* of the unit to her minus the price she pays for the unit. If a buyer does not buy a unit, her earnings for that round are zero. If a seller sells a unit in a round, his earnings are equal to the price he receives for the unit minus the *cost-value* of the unit to the seller. If a seller does not sell a unit, his earnings for that round are zero.

Resale-values as well as cost-values are strictly private information, no other participants than the concerning buyer or seller, respectively, will learn about it. Hence, every participant knows only his own earnings from a trade. Your total earnings for the experiment are equal to the sum of the earnings in each of the 18 rounds.

### Computer screen

The trading of units will take place by means of the computer. All relevant information will be available on your computer screen. You can now see what the screen will look like during the experiment.

In the top left of the screen you can see how many points you have earned up to that moment. Also the number of the present round is indicated. Below that you see how much time is left for trading in that round. For each of the 18 rounds the total time for trading is 3 minutes.

In the middle of the screen you will see a list of the relevant ask and bid-prices ("Vraag- en Biedprijzen"). An ask-price ("vraagprijs") indicates the price at which a seller is prepared to sell, and a bid-price

("biedprijs") indicates the price at which a buyer is prepared to buy. Ask- and bid-prices will be explained in more detail below.

On the right-hand side of the screen your value ("waarde") is indicated. If you are a buyer, the *resale-value* of a unit in that round is indicated. If you are a seller, the *cost-value* of a unit in that round is indicated. Resale-values may be different for different buyers, and cost-values may be different for different sellers. Also your value may change from round to round. But every buyer gets the same resale-values the same number of rounds, and every seller gets the same cost-values the same number of rounds.

In the middle left of the screen you see whether you are a buyer ("koper") or a seller ("verkoper"). Here also your ID-letter is indicated. The IDs for the buyers are A, B, C, D, E and F. The IDs for the sellers are U, V, W, X, Y and Z. Your ID will randomly change from round to round. Furthermore, IDs are not related to the cost- or resale-values. Hence, the IDs are for registration purposes only and do not convey information about the identity of participants or about their values.

In the bottom right of the screen you see a box called "Laatste actie". This box mentions the last action that is relevant to you. [Finally, at the bottom of the screen you see a long flat row. In this row you are informed about all accepted asks and bids that were in your column of ask- and bid-prices.] (Finally, at the bottom of the screen you see a long flat row. In the row you are informed about the prices of the trades that have occurred in this round.) {Finally, at the bottom of the screen you see a long flat row. If you have already traded in a round, you will see the price in this row.}

Now we will first go through the specific instructions for buyers, and then through the specific instructions for sellers. These instructions are mirror-images of each other. On your hand-out you will only find the specific instructions that concern your role in the market.

### Specific instructions for buyers

After the determination of the values and the IDs, the market opens for trading. If you want to buy a unit, and you have not yet bought a unit in that round, then you can do one of two things:

(1) You can press B (for "Bod") to make a *bid* and to enter a price at which you are prepared to buy a unit. After you press B you are requested to enter a bid-price. This bid-price must be above or equal to zero and below or equal to your resale-value ("waarde"). [After you have entered your bid-price, you must decide to which sellers you want to send your bid and which of the other buyers you want to inform about your bid. *You may send your bid to any number of sellers, but at least to one seller. You may inform any of the other buyers about your bid, but you are not obliged to do so.* Therefore, after you entered your bid-price, you are also requested to enter the ID(s) of at least one seller to whom you want to send this bid and of any of the other buyers you want to inform. Hence, you may enter as many of the seller ID-letters (U, V, W, X, Y, Z) and buyer ID-letters (A, B, C, D, E, F) as you want, but you should at least enter one seller ID-letter. Recall that the IDs change from round to round.] () {After you have entered your bid-price you must decide to which seller you want to send your bid. *You can send your bid to one seller only.* Therefore, after you have entered your bid-price, you are also requested

to enter the ID-letter (U, V, W, X Y or Z) of the seller to whom you want to send this bid. Recall that the IDs change from round to round.}

After you have entered the ID(s), your bid-price will appear in the lower middle of your screen in the column "Biedprijzen" and it is marked with an asterix (\*). Now your bid-price is transmitted to [the sellers and buyers you have entered] (all sellers and all other buyers) {to the corresponding seller}, and will appear in [their columns] (their columns) {her or his column} of bid-prices together with your ID.

[A seller who receives your bid may accept it or not. The buyers you selected can of course not accept your bid - they are only informed about it. As soon as one of the sellers accepts your bid, you will get a message in the lower-right corner of your screen under "Laatste actie", and the corresponding earnings will be calculated and indicated on your screen under "Waarde". Also all other sellers and buyers you have chosen to send your bid to will learn that your bid is accepted. Your bid-price will vanish from their column "Biedprijzen" and will appear in the row at the bottom of their screens. If your bid is not accepted by a seller, you will not get a message. Notice that it is possible that you send a bid to a seller who has already sold a unit to another buyer. Hence, receiving no message may mean that the sellers you selected to send your bid to have not yet decided about your bid, that they reject it, or that they already sold a unit.] (A seller who has not yet sold a unit in that round may now accept your bid or not. Buyers can of course not accept your bid - they are only informed about it. As soon as one of the sellers accepts your bid, you will get a message in the lower-right corner of your screen under "Laatste actie", and the corresponding earnings will be calculated and indicated on your screen under "Waarde". Also all other sellers and buyers will learn that your bid is accepted. Your bid-price will vanish from their column "Biedprijzen" and will appear in the row at the bottom of their screens.) {The seller who receives your bid may accept it or not. As soon as the seller accepts your bid, you will get a message in the lower-right corner of your screen under "Laatste actie", and the corresponding earnings will be calculated and indicated on your screen under "Waarde". No other participant will learn that your bid is accepted. If your bid is not accepted by the seller, you will not get a message. Notice that it is possible that you send a bid to a seller who has already sold a unit to another buyer. Hence, receiving no message may mean that the seller you selected to send your bid to has not yet decided about your bid, that he rejects it, or that he has already sold a unit.}

As long as you have not bought a unit in the trading round you may always revise your bid by just pressing "B", [entering a possibly new price, and entering possibly new sellers' and buyers' IDs] (and entering a possibly new price) {entering a possibly new price, and entering a possibly new seller's ID}. If you enter a new bid, your old bid will disappear. However, you are not forced to make any (new) bid. Like buyers can make bids, sellers can make *asks*. This brings us to the second thing you can do to buy a unit.

(2) You can press on K (for "kopen"). In that case you can buy one unit at one of the ask-prices that is indicated in the column "Vraagprijzen" in the upper-middle of your screen. Of course, you cannot use this option if this column is empty. If an ask-price is indicated in this column, then one of the sellers (indicated by his ID-letter) is prepared to sell a unit to you at the indicated price. If you decide to accept this ask-price you simply press K. Since there may be more than one ask-price in the column, you also need to enter the seller-ID of the ask you wish to accept. Then the trade is conducted, [your earnings are registered, and all buyers and sellers who were informed about this ask can see at the bottom of their screen that a trade has occurred at this price.] (your

earnings are registered, and all buyers and sellers can see at the bottom of their screen that a trade has occurred at this price.) {and your earnings are registered. Only the seller whom you trade with is informed about the trade and the price.}

### Summary

The experiment consists of 18 trading rounds, and each round lasts 3 minutes. You are either a buyer or a seller. In a round each buyer may try to buy one unit and each seller may try to sell one unit. For a buyer, earnings will be equal to the resale-value of the unit minus the price paid. For a seller, earnings will be equal to the price received minus the cost-value of the unit. Values are different for different traders, and they change from round to round. Buyers can try to buy by making bids or by accepting asks. Sellers can try to sell by making asks or accepting bids.

During the experiment all earnings are denoted in points. After the experiment, your earnings in cash will be determined at a rate of *1 point = 30 cents*. You will receive your earnings privately, immediately after the experiment. Your earnings are your own business, you do not have to discuss them with anyone.

### Final remarks

During the experiment, it is not allowed to talk or communicate with other participants in any way (other than through the trading). If you have a question, please raise your hand and the experimenter will come to your table. It is also absolutely forbidden to press Ctrl-Esc.

**Table 1. Dissemination of offers among clients ( $D_{\text{client}}$ ) and competitors ( $D_{\text{comp}}$ )**

session	average $D_{\text{client}}$	median $D_{\text{client}}$	% offers with $D_{\text{client}}=1$	average $D_{\text{comp}}$	median $D_{\text{comp}}$	% offers with $D_{\text{comp}}=0$
EM1	0.69	1	55	0.05	0	93
EM2	0.92	1	87	0.09	0	89
EM3	0.94	1	88	0.10	0	87
EM4	0.87	1	82	0.24	0	74
all EM sessions	0.85	1	77	0.12	0	85

**Table 2. Average absolute difference between actual prices and equilibrium price range**

session #	EM	DA	DBM
1	0.54	0.57	2.04
2	0.88	1.72	1.26
3	0.67	1.49	1.76
4	1.08	0.61	1.31
all sessions	0.79	1.1	1.59

**Table 3. Average degrees of inefficiency and number of inefficient rounds**

session #	% of inefficiency			number of inefficient rounds		
	EM	DA	DBM	EM	DA	DBM
1	1.77	1.48	6.31	3	3	13
2	0	0.25	7.83	0	1	11
3	1.26	1.26	9.34	4	3	11
4	0.76	1.77	5.30	2	4	6
all sessions	0.95	1.19	7.20	9	11	41

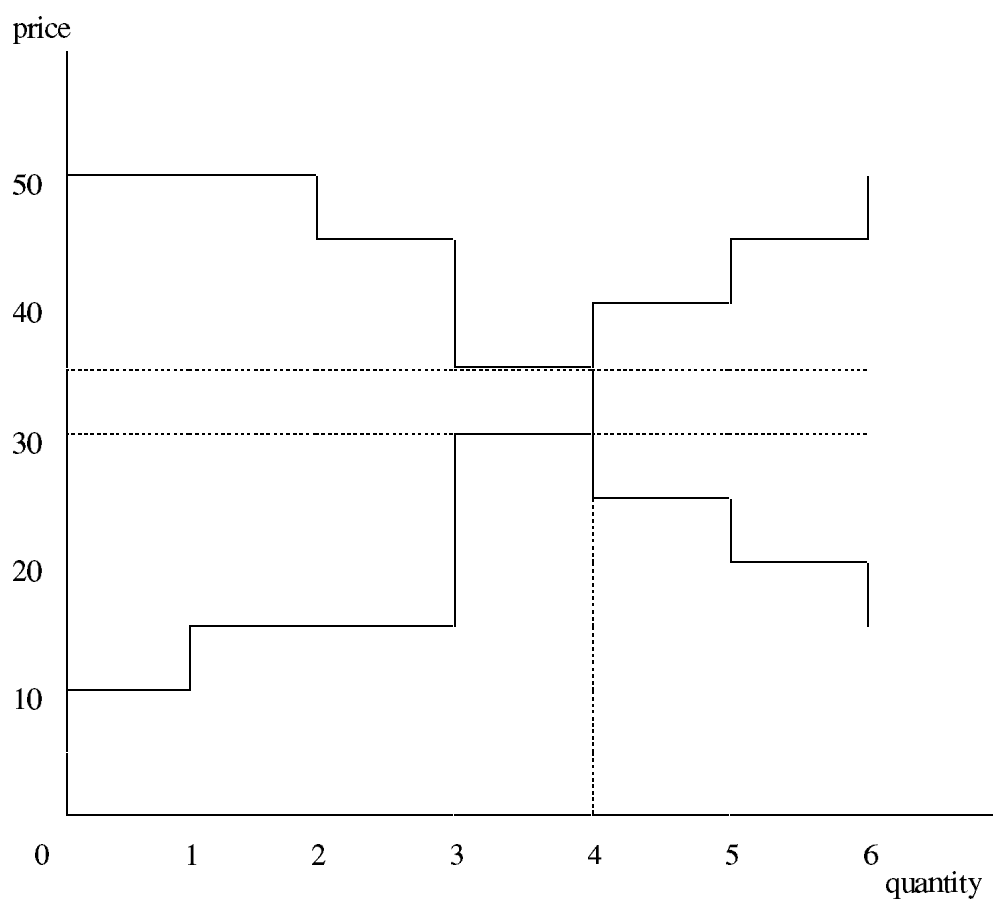


Figure 1: The induced demand and supply schedule